This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

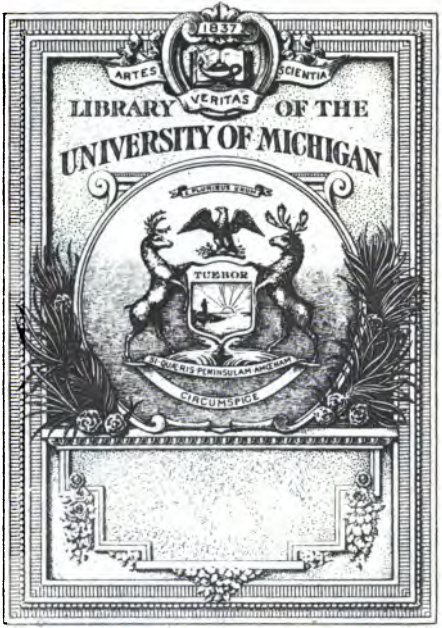
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



THE GIFT OF
Mrs. N. M. Langdon

QC
605
.M37

SMALL ACCUMULATORS

HOW MADE AND USED

An Elementary Handbook for the use of Amateurs and Students

EDITED BY

PERCIVAL MARSHALL, A. I. MECH. E.

FULLY ILLUSTRATED

NEW YORK:
SPON & CHAMBERLAIN, 12 CORTLANDT ST.

LONDON:
E. & F. N. SPON, LIMITED, 125 STRAND.

1899

Entered according to Act of Congress in the year 1899
BY SPON & CHAMBERLAIN
in the office of the Librarian of Congress, Washington, D. C.

THE BURR PRINTING HOUSE, NEW YORK, U. S. A.

Gift
Mrs. N. M. Langdon
12-13-27

PREFACE.

THE subject of small accumulators has been selected for treatment in this, the first of a series of popular scientific hand-books for students and engineers, by reason of the large number of requests for advice which have reached me in my capacity as editor of *The Model Engineer and Amateur Electrician.* Although some of the information herein contained has already appeared in the pages of that journal, I believe that the connected and amplified form in which this is now presented will make it of greater utility and more convenient for reference. Sufficient matter has been added to make the book cover the ground indicated by its title as fully as is possible, but the limited space available precludes any pretence to exhaustive treatment of the subject. I venture to hope, however, that this little volume will be found a practical and trustworthy

guide to the particular class of readers for whom it is intended. I take this opportunity of acknowledging the valued help of Mr. Harold H. Simmons, A.I.E.E., who has been good enough to revise the proofs, and to add a glossary of electrical terms which will much facilitate the easy comprehension of the subject by the non-technical reader. To the Photogram, Ltd., my thanks are due for kind permission to reproduce from their book, *Practical Radiography,* some of the illustrations and instructions contained in Chapter III.

PERCIVAL MARSHALL.

CONTENTS.

CHAPTER I.

PAGE

THE THEORY OF THE ACCUMULATOR, . . 7

CHAPTER II.

HOW TO MAKE A FOUR-VOLT POCKET ACCUMULATOR, ... 14

CHAPTER III.

HOW TO MAKE A TWELVE-VOLT ACCUMULATOR, ... 21

CHAPTER IV.

TYPES OF SMALL ACCUMULATORS, . . 30

CHAPTER V.

HOW TO CHARGE AND USE ACCUMULATORS, 40

CHAPTER VI.

APPLICATIONS OF SMALL ACCUMULATORS, . 59

USEFUL RECEIPTS, ... 76

GLOSSARY OF TECHNICAL TERMS, . . 79

SMALL ACCUMULATORS.

CHAPTER I.

THE THEORY OF THE ACCUMULATOR.

AN accumulator is an appliance for accumulating or storing electricity, and its working depends upon the chemical changes undergone by certain substances when subjected to the action of an electric current. Accumulators are also known as " storage " or " secondary " batteries.

Strictly speaking, it is not correct to say that electricity is stored in an accumulator, although, as far as external results are concerned, such appears to be the case. What really happens is this. The charging current, *i.e.*, the current which feeds electricity into the accumulator, produces a gradual chemical change or decomposition in the active elements of which the appliance is constructed, such change continuing to take place so long as the

charging current is applied. As soon as this current ceases, however, so also does the chemical decomposition of the constituents cease; and if the terminals be then connected by a wire a reversal of the process commences. That is to say, the disunited particles gradually re-form themselves into their original chemical combinations, and by so doing produce a current of electricity which flows in the opposite direction to that originally used for charging.

An early form of accumulator, though more of experimental than practical interest, was Grove's gas battery. This was composed of a series of cells, each cell comprising two tubes, closed at the upper ends, and dipping down into a glass jar containing acidulated water. Each tube had a platinum wire fused into the closed end, from which a strip of platinum foil extended downwards into the liquid. The outer ends of the platinum wires were provided with brass terminals, by means of which several of these cells were connected together. A charging current from a primary battery was then applied and resulted in the gradual decomposition of the water in the various glass jars. Hydrogen collected on one of the platinum plates in each of the cells and oxygen on the other. If after a short time the primary

battery was disconnected from the wires joined to the outer terminals of the cells and a galvanometer substituted, it was found that a current would then flow in the reverse direction until all the separated hydrogen and oxygen gases had re-combined to form water again.

From a practical point of view, the gas battery was deficient, inasmuch as it would only supply current for a very short time, and several workers set themselves the task of contriving an arrangement to obviate this defect. The most successful of these early workers was Planté, and he found in the course of his experiments that the best results were to be obtained by using lead plates or electrodes in a dilute solution of sulphuric acid. He made a cell by taking two long strips of sheet lead, placed one over the other with pieces of insulating material between, and coiling these up into spiral form. These plates were provided with separate terminals and were placed in a jar containing a solution of sulphuric acid. The action of the charging current was to decompose the water in the solution, the oxygen combining with the metal of the positive plate and thus forming peroxide of lead, whereas the hydrogen was simply deposited

on the negative plate and there remained in gaseous form. On discontinuing the charging current, the hydrogen combined with oxygen in the solution to form water again, while the peroxide of lead was deoxidised, the lead remaining on the surface of the plate as spongy lead, and the oxygen re-entered the solution to compensate for the oxygen which was extracted therefrom by the hydrogen in forming water. Planté found that this method of construction enabled him to get an electro-motive force (E.M.F.) of from 2 to 2.5 volts, as against 1.47 volts given by Grove's gas battery.

Planté's experiments did not, however, terminate with this achievement, and he next introduced a method for considerably increasing the available metallic surface of the electrodes. This plan is known as "forming" the plates, and consists of repeating for a considerable time the following series of operations: (*a*) charge the accumulator, (*b*) discharge ditto, (*c*) re-charge, but with the charging current entering in the reverse direction, (*d*) again discharge. This cycle or series of reversals in charging and discharging, if kept up for several days, has the effect of causing the lead plates to become very porous or spongy

in character, and, therefore, by reason of the additional surface of contact between electrolyte and electrode thus provided, enables the cell to retain a much greater charge than it would otherwise do.

It is not difficult to see that this work of "forming" is of a somewhat tedious and expensive character, and with the object of reducing this process to a minimum, another inventor, Faure, conceived the idea of using plates coated with a paste of lead-oxide, a plan which made it possible to use an accumulator with success after being charged only two or three times. When first introduced, some difficulty was found in making the lead-oxide paste adhere properly to the plates, and various means were devised to overcome this drawback. Scratching and indenting the lead plates was tried, but this was ultimately superseded by the plan of making perforated plates in the form of grids, the paste being pressed into the perforations. With various slight modifications in the shape of the perforations this device has been found to answer exceedingly well, and is now very generally adopted.

When an accumulator is freshly charged it will be found to have an E.M.F. of about 2.25 to 2.5 volts, but after being used a short time

this falls to about 2 volts, at which figure it remains until the cell is nearly exhausted. For many purposes, however, a higher voltage than this is required, and it then becomes necessary to have several cells joined in series, so as to give a total voltage equal to the number of cells multiplied by 2. Thus three cells of 2 volts each if joined in series would give an E.M.F. of 6 volts, five cells would give 10 volts, and so on.

The current which a cell will accumulate or store depends upon the area of its plates—the larger the plates the greater the capacity of the cell, and, further, the higher the permissible rate of discharge. As it is not always convenient to use very large plates where great capacity is required, the same result may be obtained by using a number of small plates to increase the available plate surface, but in such cases the plates must be connected in parallel. That is, the positive plates must all be connected to one terminal, and the negative plates all to the other terminal, thus forming practically two plates divided into a number of branches.

The capacity of an accumulator is usually measured in ampère-hours. Thus an accumulator which will discharge a current of ten

ampères for one hour, or of five ampères for two hours, or of one ampère for ten hours, is said to have a capacity of ten ampère-hours. As a general rule, it may be reckoned that an accumulator with its plates connected in parallel has a capacity of six ampère-hours for each square foot of positive plate surface.

CHAPTER II.

HOW TO MAKE A FOUR-VOLT POCKET ACCUMULATOR.

FROM the preceding chapter the reader will have gathered that an accumulator to give an E.M.F. of 4 volts must have two separate cells, each giving 2 volts, with the elements connected together in series, *i.e.*, the positive plate of one cell to the negative plate of the other. The first thing, therefore, is to construct a two-celled case, as shown in Fig. 1, of such size as may suit the user's pocket. As previously explained, the size of an accumulator has a proportional effect upon its capacity, and in the example chosen for illustration the dimensions are such as to give a capacity of from 1½ to 2 ampère-hours.

The case should be made of sheet gutta-percha, which can be purchased at any shop where india-rubber goods are sold. The gutta-percha should be cut into pieces of the required size, as shown in the drawing, and

these should be joined together by passing a hot iron over the edges forming the joints and

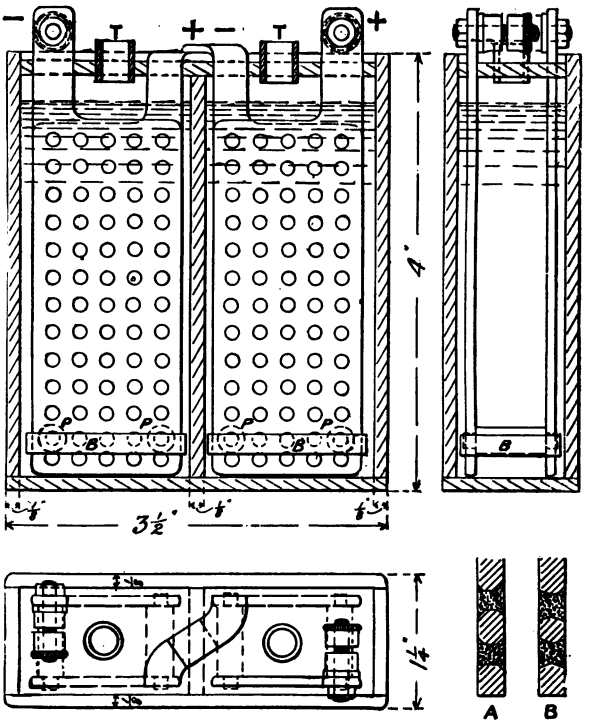


FIG. 1.—FOUR-VOLT POCKET ACCUMULATOR.

well pressing the pieces together. If preferred, a vulcanite case of suitable size can be pur-

chased ready made. The outside dimensions of the finished accumulator are 3½ ins. wide, 4 ins. high, and 1¼ ins. deep; and the thickness of the material used should be about ⅛ in. The case is divided into two cells by a division piece in the centre, as shown. It is, of course, essential that all the joints be thoroughly well made to prevent any leakage.

The plates may be cut out of sheet lead about 3.32nds. or ⅛ in. thick, and should measure 3¼ ins. deep by 1¼ wide. At the top end each plate should have a projecting strip or lug about 1¼ ins. long and ½ in. wide. Each plate should be drilled or punched with a large number of small holes about ⅛ in. diameter, each hole being afterwards countersunk on both sides of the plate as shown at section A. If several accumulators are required, or a number of plates, a quicker plan would be to cast the plates in a plaster-of-Paris mould, in which case the perforations could be rather larger and of the shape shown in section B. Full instructions for casting accumulator plates will be given in the next chapter. The object of countersinking the holes, or of making them taper inwards from each side, is to enable the plates to better retain the lead-oxide paste with which they have to be subsequently coated.

For the accumulator now being described, four plates will be required, two positive and two negative, one pair for each cell.

The two positive grids will require pasting with a stiff paste made of red lead and dilute sulphuric acid (one part acid to two parts water). The best way of doing this is to lay the grid flat on a sheet of glass, and press the paste into the perforations with a horn or wooden spatula. The grid should now be turned over and the other side treated in the same way, after which it must be stood up in a warm room to allow it to dry, for about fifteen hours. Having pasted and dried both plates, the next thing is to place them in a very strong solution of chloride of lime. This will form lead peroxide, and save the trouble of "forming." When the action is complete the plates must be washed in clean water; they are then ready to be placed in the cell.

The negative grids must be filled in with precipitated lead. To make this, place a few strips of zinc in a saturated solution of lead-acetate, and collect the crystals that are formed. These will adhere together when pressed into the grid.

Before putting the plates together, each negative should have a pair of ebonite separat-

ing pins (P) fixed along the bottom so as to keep it about ¼ in. apart from the positive plate. These pins will then fit into the positive plate, when a rubber band (B) will make the whole fast.

The plates should then be placed in the cells in the position shown, the two lugs in each cell being at opposite ends, and so turned that the positive plate in one cell and the negative plate in the other have their lugs toward the centre. The lid of the cell may be made of hard wood, which should be well soaked in hot paraffin wax. It must have four slots cut in it to allow the lugs to pass through, and also two round holes between the slots to receive two short pieces of ¼-in. ebonite tubes (T T) which should be cemented therein. The lid should then be placed on and firmly sealed down with marine glue.*

The lugs in the centre must be bent down so as to meet each other, and are then neatly soldered together. The two outer lugs have a hole drilled through each, to receive brass terminals secured by back nuts as shown. A mark, thus +, should be marked against the positive terminal, so as to identify it when charging. Any superfluous portions of the

* See "Useful Receipts."

lugs should, of course, be carefully cut away, to make a neat finish.

Each of the two cells should now be filled through the tubes (T T) with the electrolyte or acid solution. This consists of pure sulphuric

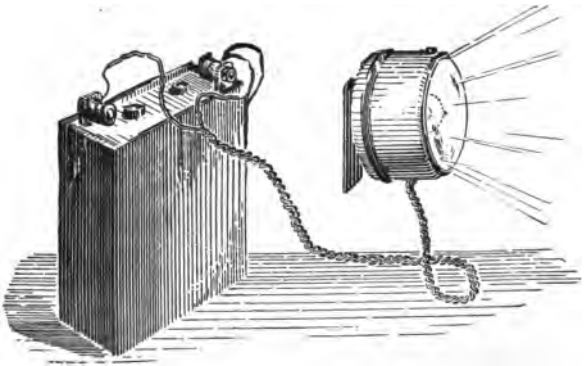


FIG. 2.—FOUR-VOLT ACCUMULATOR CONNECTED TO CYCLE LAMP.

acid, diluted with about four times its bulk of water, the specific gravity of the mixture being about 1.17. When preparing this mixture the acid should be poured *very slowly* into the water and never *vice versa*. The quantity of solution should be sufficient to cover the plates in each cell, but not to completely fill the interior of the accumulator. The tubes (T T) should then be fitted with removable

vulcanite or rubber plugs, and the cell is ready for charging.

Fig. 2 shows the finished accumulator as it actually appears, connected to a cycle lamp.

CHAPTER III.

HOW TO MAKE A TWELVE-VOLT ACCUMULATOR.

THE accumulator described in this chapter is intended to give an E.M.F. of 12 volts and to have a capacity of 32 ampère-hours. That is to say, it will be capable of supplying a current of 1 ampère for thirty-two hours or 4 ampères for eight hours, and so on. There is, however, a limit to the rate at which it is desirable to discharge any particular accumulator, and in the present instance the rate of discharge should not exceed about eight ampères.

The body of the accumulator is made of hard wood such as teak, and should be lined with sheet ebonite. As it is to give 12 volts, it is obvious that there must be six separate cells, as shown in fig. 3, these being obtained by fixing suitably arranged ebonite partitions across the inside. Each cell must contain seven plates (three positive and four negative), each plate measuring $8 \times 6\frac{1}{2} \times \frac{3}{16}$ ins. In

accumulators of any size it is better to have one more negative plate than the number of positives, there then being a negative on each side of the positive plates. Thus, in a cell having three positives there would be four negatives. This arrangement tends to distribute the current evenly over the plates, and thus prevent the positive plates from buckling.

The lead plates or grids, fig. 4, forty-two of

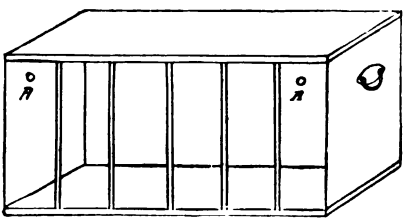


FIG. 3.—CASE FOR TWELVE-VOLT ACCUMULATOR.

which will be required, should be cast in a plaster-of-Paris mould as follows:—First, make a plaster slab of sufficient size to allow a 2-in. margin all round the edge of the grid to be cast, and from one to two inches in thickness. Then draw upon its surface a facsimile of the grid as in fig. 5. The plaster must then be cut away within the marked-off lines to the depth of about $\frac{1}{16}$ in., this being done with a small chisel. A pouring hole must be made at B,

which also forms the lug of the plate; an air-hole at C; and a few cuts at D D, at convenient intervals for aligning the cover of the mould when fixing in position for casting.

To complete the mould an exact counterpart of the half already cut will be required. This can be made by filling up all the grooves (except those at D D) in the mould just made with heated paraffin wax, pressing it into place

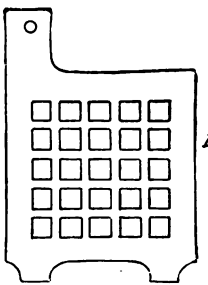


FIG. 4.—LEAD PLATE OR GRID.

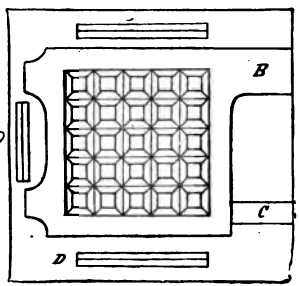


FIG. 5.—PLASTER MOULD.

with the fingers, and scraping off level with the face of the mould, thus forming a pattern of one side of the grid. When hard, the wax may be removed by inserting a pin at one corner. It will again be necessary to fill in the grooves to prevent the plaster running into them, and scrape off level as before. The impression already taken should next be laid on its back on the wax at present in the grooves,

and a little shellac varnish applied to the mould with the wax pattern in position. A wall of wood must now be arranged around, projecting from 1 to 2 ins., according to the depth of the other half, and the plaster run in. When hard, the mould may be taken apart and all wax removed, the two halves wired together, and the casting proceeded with. The lead used must be pure, and melted in a thoroughly clean

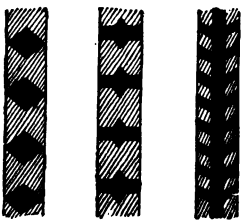


FIG. 6.—SECTIONS OF GRIDS SHOWING DIFFERENT STYLES OF PERFORATIONS.

ladle, or contamination with zinc or other similar metal might result, which would be fatal. It is advisable to cast a few grids over and above the number required, as some may be found to be defective when the process of pasting is commenced. The sections shown in fig. 6 illustrate different styles of perforations or recesses made in accumulator plates, either of which may be adopted in the present case.

Pasting, or filling in the grids with the oxides of lead, must now be attended to, the positive grid being filled in with a stiff paste made of red lead and dilute sulphuric acid (one part acid to two parts water). This is most conveniently done by laying the grid flat on a smooth board and pressing the paste into the perforations (which it will be noticed are wedge-shaped for the purpose of holding the oxide as securely as possible in place, and measure $\frac{1}{4}$ in. square on the surface) with a wooden spatula.

The grid should then be turned over, and the other side similarly treated, when it may be stood on end in a warm place to dry, which will take from twelve to twenty-four hours. When properly dry, the plate is placed in a concentrated solution of chloride of lime which gradually converts it into lead peroxide, thus avoiding the necessity of further "forming."

After the action is complete, the plate may be rinsed in clean water, and will then be ready for use in the cell.

The negative grid, instead of being pasted with litharge and sulphuric acid, as is usual, may be filled in with precipitated lead. This is obtained in the form of crystals by lowering a strip of zinc into a saturated solution of ace-

tate of lead; the crystals will then form on the zinc.

These crystals are very thin, and possess the property of being able to adhere firmly together, forming a soft fibrous and porous mass, which must be gathered and kept under water until sufficient for one grid has been collected, when they may be pressed into the grid. The

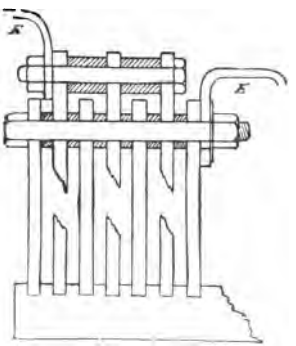


FIG. 7.—METHOD OF CONNECTING THE PLATES.

plates may now be fitted in their cells, and charged for use, requiring no further forming process.

The plates are placed side by side in the cells as in fig. 7 at a distance of $\frac{1}{4}$ in. apart, and are kept separate by means of celluloid or hard wood racks, as shown in fig. 8. If wooden

racks are used they should be previously thoroughly soaked in melted paraffin wax. These racks at the bottom are also useful for keeping the lower ends of the plates well above the bottom of the containing vessel. This is important, as it allows any active material which may become detached from the plates to fall away clear of them. If the material

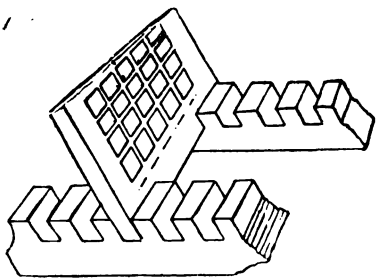


FIG. 8.—RACKS TO SUPPORT PLATES.

remained between the plates it might bridge the narrow gap and thus short-circuit the cell. As the negative plates exceed the number of positives in each cell by one, and they are placed in the cell one negative and one positive alternately, the two outside plates will be grey negatives with brown positives next to them, and afterwards negative and positive and alternately.

The whole of *the positive plates* in each cell will need to be *coupled together,* the same applying to the negative. The lug of each plate is punched with a ¼-in. hole through which is passed a screwed brass rod, and the plates are firmly fixed by means of nuts and washers, as in fig. 7. After all the connections have been made, the brasswork should preferably be coated with paraffin wax or anti-sulphuric enamel to protect it from the corrosive action of the acid fumes. When the plates are thus connected in their cells, the positive coupling of one cell must be connected with the negatives of the adjacent cell, and so on right through the battery. The method of this connection is shown at E (fig. 7), which represents the form of lead strip used. There will then be a positive coupling or section left at one end of the battery, and the negative section at the other, which are to form the poles of a battery and are best dealt with by soldering them to brass terminal screws which appear on the outside of the containing vessel.

The battery is now ready for *the electrolyte or acid* to be run in, and, for the type of cell here described, sulphuric acid of 1.19 specific gravity will be required. The acid used must be pure brimstone acid, and none other. This will

require diluting with about four times its quantity of water to bring it to the above-mentioned specific gravity. In mixing, always add the strong acid to the water, not *vice versa,* for in the latter case the mixture sprays violently in all directions. This mixture should well cover the tops of the plates. Everything should be in readiness so as to start charging without delay as soon as electrolyte has been run in.

CHAPTER IV.

TYPES OF SMALL ACCUMULATORS.

ALTHOUGH in the previous two chapters full instructions have been given whereby the reader may construct his own accumulators, it is probable that there are many who will prefer to purchase the appliances ready-made. The following descriptions of modern commercial forms of small storage batteries will therefore doubtless be of interest.

The smaller kinds of portable accumulators are usually known as "pocket" accumulators, presumably on account of their dimensions rendering them suitable for carrying in one's pocket if need be. Fig. 9 illustrates a 2-volt accumulator of this kind, having a capacity of 3 ampère-hours. Its dimensions are 4 ins. high × $2\frac{1}{8}$ ins. wide × 1 in. thick, and its weight is 15 oz. It will be noted that this cell is of a curved shape, to make it better fit the pocket. A somewhat larger accumulator, rectangular

in form, is shown in fig. 10. This also gives an E.M.F. of 2 volts, but has double the capacity, viz., 6 ampère-hours. Its dimensions are $5 \times 3\frac{7}{8} \times 1\frac{1}{8}$ ins. and the weight 2 lb. 3 oz. As usual with accumulators of this size the cases or cells are made of the best ebonite, while in these cells the plates are separated by ebonite forks. Ebonite covers are provided both

FIG. 9.—TWO-VOLT CURVED POCKET ACCUMULATOR.

above and below the sealing composition. The lead connections are carried through these covers to terminals well insulated from the acid. Each cell is provided with a screw vent peg. In fig. 11 and fig. 12 are shown accumulators similar in construction, but arranged to give 4 and 6 volts respectively. It will be ob-

served from the illustrations that the number of vent pegs shown indicate the number of separate cells inside the accumulator, one vent peg being required for each cell.

In constructing accumulators of a larger size, a seasoned hard wood, such as walnut, mahogany, or teak, is usually employed in

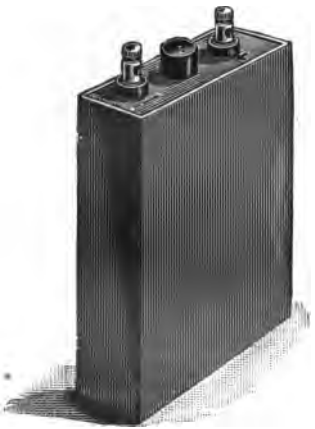


FIG. 10.—TWO-VOLT RECTANGULAR POCKET ACCUMULATOR.

place of ebonite for the outer casing. A 12-volt wood-case accumulator of 2 ampère-hours capacity is illustrated in fig. 13. This has a sliding lid, and also a leather strap for carrying purposes. The terminals, as illustrated,

are let into the side of the box and are intended to take plug connections, but screw terminals may be fitted if desired. Other types of portable accumulators are illustrated in fig. 14 and fig. 15. These are supplied either with teak cases ebonite-lined, or with teak cases lead-lined, the latter being slightly more expensive.

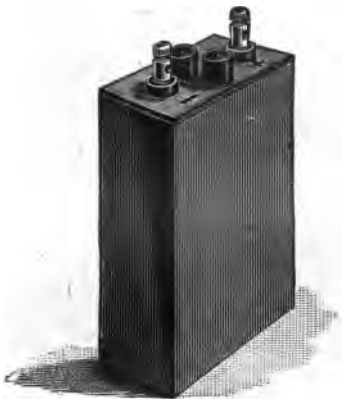


FIG. 11.—FOUR-VOLT POCKET ACCUMULATOR.

The capacity of the type shown in fig. 14 varies from 7 to 70 ampère-hours, and of that in fig. 15 from 16 to 32 ampère-hours, according to the number of plates in each cell. Fig. 14 is used chiefly for small lighting plants, portable lamps, cycle and carriage lamps, x-ray coils,

table decorations and night-lights, while fig. 15 is generally preferred for cautery operations, working phonographs, etc.

For medical purposes, portable accumulators are of great utility, and fig. 16 shows a battery in a polished walnut or mahogany case, arranged specially for such work. It has five

FIG. 12.—SIX-VOLT POCKET ACCUMULATOR WITH LAMP.

terminals projecting from the side, and by suitably connecting these up, an E.M.F. of either 4, 6, or 8 volts can be obtained. Should a higher voltage be required, as for example for some cases of electrolysis, a 6-volt pocket battery can be carried, which if connected in series with the main set of cells, will allow an E.M.F. of 14 volts to be obtained. If required

for cauterisation, a special resistance can easily be fitted to the accumulator here illustrated. The capacity of this battery is 30 ampère-hours.

The principal difference in the construction

FIG. 13.—TWELVE-VOLT PORTABLE ACCUMULATOR.

of the various makes of accumulators now on the market, lies in the materials and methods adopted for constructing the plates. Thus in one type of cells the plates, which are of lead, are cast in the form of grids with square apertures, into which a paste is pressed, minium being used for the positive, and litharge for

the negative grids. In another type, a lead grid, or indeed a metallic support of any kind, is dispensed with, the plates being made up by combining oxides of lead with some fibrous material such as hair or asbestos fibre, the latter serving to bind the whole together. The

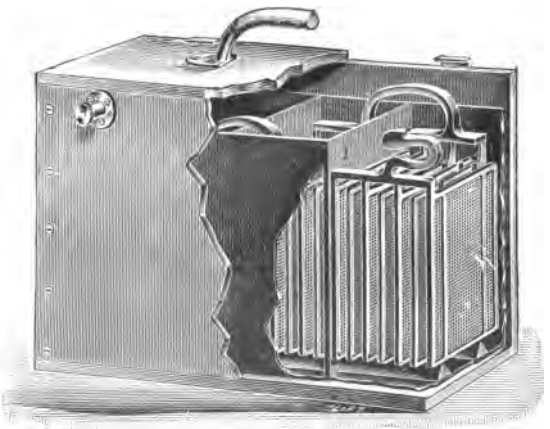


FIG. 14.—PORTABLE ACCUMULATOR.

mixture, after being worked into a proper consistency, is pressed into a mould, and a strip of lead or platinum inserted to act as a connecting piece. This mode of construction obviously enables an appreciable saving in weight to be gained.

In the "Allan" accumulator a specially mixed paste is supported or contained in a hollow lattice frame cast in one piece, the active material being thus supported in an unbroken mass throughout the frame. This peculiarity

FIG. 15.—PORTABLE ACCUMULATOR.

of construction is said to give great freedom from buckling, and the composition of the special paste is such as to enable almost any degree of hardness to be obtained during forming, without detracting from the power to discharge at a high rate. Another plan of con-

structing the plates is that adopted in the Pitkin accumulators. Each plate presents a flat surface, studded with a number of small projecting pins, and having a raised rim or bead running round the edge. The pins are all

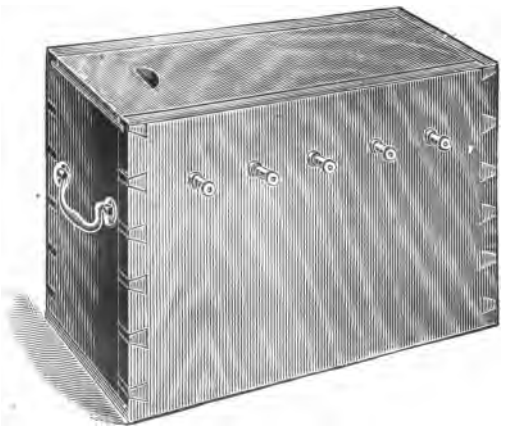


FIG. 16.—PORTABLE ACCUMULATOR FOR MEDICAL WORK.

hammered or otherwise burred over at the tops, thus affording a secure hold for the active material or paste which is pressed closely into all the intervening spaces.

Yet another type of storage battery is that known as the lithanode accumulator. Lithanode is a material made from litharge and sulphate of ammonia, and contains from 80 to 90

per cent. of peroxide of lead. The plates in the lithanode accumulators consist of metallic grids into which several pellets or small slabs of lithanode are firmly inserted. The positive pellets are converted into peroxide of lead in a forming bath, the negative pellets being reduced to spongy lead by the ordinary electrolytic method.

CHAPTER V.

HOW TO CHARGE AND USE ACCUMULATORS.

THE source of the charging current may be one of the following:

(*a*) Battery;
(*b*) Thermo-Electric Generator;
(*c*) Public Supply Main;
(*d*) Dynamo.

Charging E.M.F.—This must not be less than 2.5 volts for each cell to be charged. Of course, alternating current is useless for this purpose. Supposing we have ten cells to charge in series, then we must have 10 by 2.5 $=25$ volts to charge. But by arranging the 10 cells in two sets of 5, and then putting these two sets in parallel as in fig. 17, we can charge them with only 12.5 volts. Unless, however, we send double the current, so as to send the same current through the cells, it will take twice as long to charge them as it did when we had them in series. To make this

more clear, supposing the ammeter A_1, in fig. 17, to read 4 ampères, then the other ammeters, A_2 and A_3, would each read 2 ampères. If, however, we have only 5 volts at our disposal for charging, then we shall have to arrange our cells in five sets of two each, and put the five sets in parallel as in fig. 18, and instead of taking twice as long to charge them, it will take

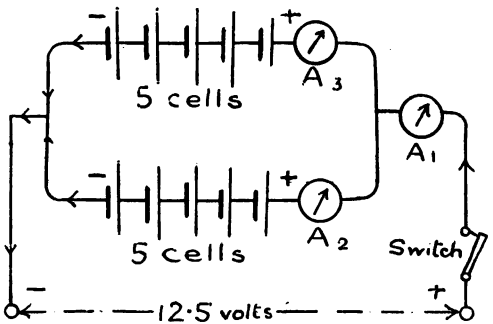


FIG. 17.—CHARGING 10 CELLS, IN TWO SETS, IN SERIES.

five times as long, since each set of cells only gets one-fifth of the current given by the dynamo. If, therefore, we wish to charge them in the same time as in the first case, we must supply five times the current.

The charging current for a cell should not greatly exceed 4 ampères per square foot of positive surface.

Charging from Batteries.—Charging by primary batteries, though, comparatively speaking, expensive, will be found suitable in many cases for small capacity cells, where there is no other means available. The Bunsen or Grove cells are the most satisfactory for the purpose, on account of their high E.M.F. (which is

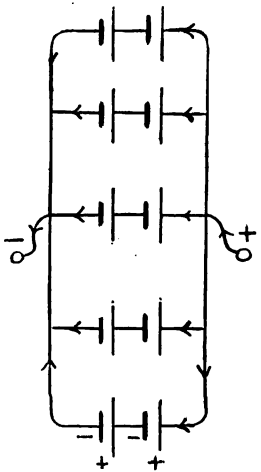


FIG. 18.—CHARGING 10 CELLS, IN FIVE SETS, IN PARALLEL.

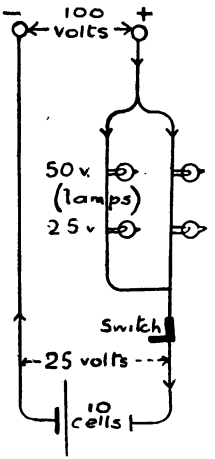


FIG. 19.—CHARGING 10 CELLS FROM 100-VOLT MAIN.

about 1.9 volts) and their very small internal resistance, but of the two the Bunsen cell is the one more generally used, and a short description of this cell is given, as the parts may be bought and made up by the amateur.

Parts Required.

	Size in inches. Inside.	Outside.
Earthenware jar, .	6 by 4	6¼ by 4½
Porous pot, . .	5½ by 2¼	5¾ by 2½
Cylindrically shaped zinc . . .	5¼ high by 3½ diameter	
Carbon block, ...	6 by 1 by 1	

Two clamps, one to make connection with the carbon, and the second for zinc.

The zinc should be very carefully amalgamated as follows:—A small quantity of mercury is poured into an earthenware or glass vessel, to which a little hydrochloric acid is then added. The zinc is immersed and then taken out and cleaned in water. This should be done in an outhouse or workshop, as the hydrochloric acid gives forth very obnoxious odours.

Another way to amalgamate the zinc is by leaving it a short time in sulphuric acid, and then immersing the zinc in the mercury, but this is a much slower process than the first, as the sulphuric acid does not act so quickly. Or again, the zinc may first be immersed in acid, and the mercury applied with the aid of a short piece of stick and a tuft of flannel.

The zinc is placed in the earthenware jar,

then in the centre of the zinc the porous pot, and within this the carbon block.

To charge the cell, fill the outer jar three-quarters full with dilute sulphuric acid (one part of acid to ten of water) and the porous pot with nitric acid, after which the battery will be ready for work. Great care should be exercised to see that all the metal connections are clean, and to obtain this result it is best to *file* the portions that make contact, as by using mercury or sandpaper particles might adhere and weaken the contact.

As the current from the primary causes an opposing E.M.F. in the secondary element, it is necessary that the current from the charging station should have a higher E.M.F. than the secondary battery or accumulator. For instance, if you are charging twenty batteries of 2 volts each, joined in series, it will be necessary that the primary current should have a higher E.M.F. than 40 volts (20 by 2).

Four Bunsen cells with one charge and joined in series will be sufficient to charge a small 4-volt accumulator, and having determined the charging station (whether from batteries or other means) the procedure will be the same, with the exception that a resistance will not be required, unless in the case of charging

from a dynamo, or by using a very large accumulator.

Charging from Thermo-Electric Generators.—These have, of late years, been much improved, and can be conveniently used for charging, being less costly to work and far cleaner than batteries. The Glülcher thermopile is a durable type, and gives on short circuit about 5 ampères at 4 volts, using from 5 to 7 cubic ft. of gas per hour. Although thermopiles are very convenient sources of electrical energy for this class of work, it can hardly be said that they have a very high efficiency.

Charging from Public Supply Mains.—When it is possible to get a connection with a direct current supply circuit, this is one of the best and cheapest means of charging small accumulators. In the case of house mains, a very convenient connection can be made by means of the wall plug used for movable lamps; or a connection may be had on the ceiling-rose. In any case it will be wise to mark the poles in order to avoid mistakes. The poles of the charging wires can be easily found by taking a piece of "pole-finding paper," * wetting it, and then putting a wire

* See "Useful Receipts."

from the positive and another from the negative terminals on the paper, within about ½ in. from each other, taking care that the two wires do not touch; keep them in this position for a few minutes, and on removing, a red mark will be left on the paper, indicating that the wire which left the mark is the negative. If pole-finding paper is not to hand, take a glass of water and immerse the two wires, keeping them the same distance apart from each other as before, and the negative wire will produce a great many more bubbles than the positive.

It will be necessary to reduce the voltage by means of some resistance. Perhaps the readiest method of doing this will be to connect a number of incandescent lamps in series with the cells. For instance, fig. 19 shows the connections for charging ten cells from 100-volt mains, the charging voltage being $100 - (50 + 25) = 25$ volts. The voltage can thus be varied at will by altering the lamps connected in series with the mains. Unless, however, the amateur is used to electrical work, he had better call in an electrician to advise him, as lighting mains are not to be played with. The lamps placed in series should take the same current as the cells require. Suppose the cells require 2 ampères, and the lamps only take 1

ampère, then two lamps will have to be inserted in parallel, as shown in fig. 20.

To connect two or more accumulators in series, they should be joined up thus :—positive of the first cell to negative of the second, and

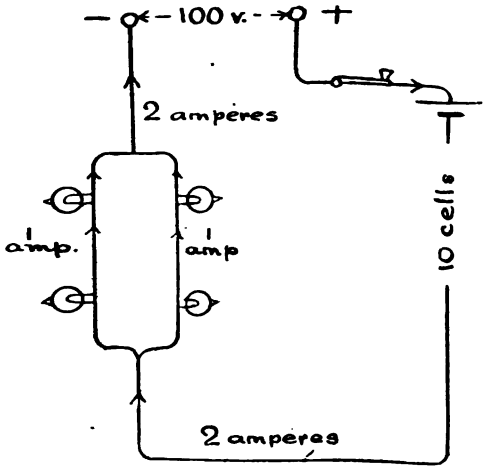


FIG. 20.—CHARGING 10 CELLS FROM 100-VOLT MAIN.

the positive of the second cell to negative of the third, and positive of the third will connect on to positive terminal from the charging station, and the negative pole passed through the lamp resistance, the second terminal of the lamp to one terminal of the ammeter; and the

second terminal of the ammeter to the negative wire of the charging circuit.

Failing sufficient E.M.F. to charge all the

FIG. 21.—CHARGING BOARD.

cells in series, the most satisfactory arrangement for charging large secondary cells is to connect them in series forming groups, then connect these groups in parallel. The number

of cells placed in groups should be decided by the E.M.F. of the charging batteries. The current required to charge accumulators varies with the size of plates. For very small cells the basis of calculation may be taken as 6 ampères per square foot surface of positive plate.

L = length of plate in inches.
W = width " " Then

$$\text{Current required} = \frac{L \times W}{12} \times \text{number}$$

of positive plates in single compartment.

A very simple and neatly arranged charging board is shown in fig. 21, which is connected underneath as fig. 22.

The positive wire taken from bracket is taken to one terminal of the board, and the negative, after passing through the resistance, is taken to the second terminal. When the board has been once arranged, all that is necessary to put the accumulators on charge is to place the plug in the bracket and to connect the positive of accumulator to the positive of board, and the negative of accumulator to negative terminal.

Charging by Dynamo.—The dynamo will, of course, be used by most readers for charging. If the amateur has a small gas or steam engine to drive his dynamo, he will then be able to charge his accumulator very cheaply and with

little trouble. For charging small cells, a tripolar machine is very handy; but for larger cells

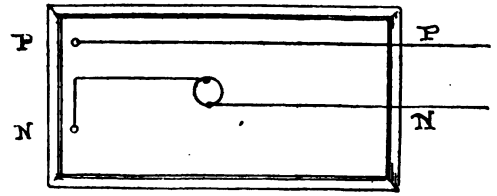


FIG. 22.—CONNECTIONS OF CHARGING BOARD.

a drum or ring armature machine should be used. The dynamo must be shunt-wound, the reason for this being that if the dynamo should

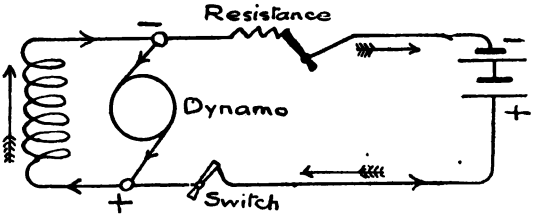


FIG. 23.—SHOWING FLOW OF CURRENT IN SHUNT-WOUND DYNAMO.

fail to give current, the accumulators will not reverse the field, as they would do if a series machine were used. Figs. 23 and 24 will make this clear, the arrow-heads on the lines showing

the dynamo current, and the complete arrows showing the direction of accumulator current

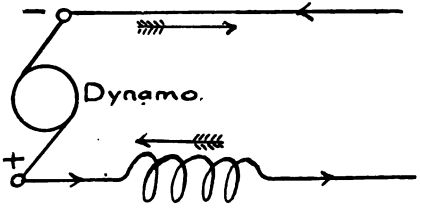


FIG. 24.—SHOWING FLOW OF CURRENT IN SERIES-WOUND DYNAMO.

if the dynamo should stop. In the case of the series machine (fig. 24), it will be noted that

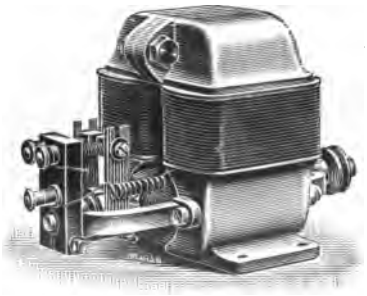


FIG. 25.—SMALL CHARGING DYNAMO.

in such a condition the field would be reversed. Hence series-wound dynamos cannot be used for accumulator charging. Fig. 25 shows a

small drum armature dynamo, specially designed for charging portable accumulators. This machine gives 2 ampères at 10 volts.

Connecting up the cells will present no difficulty to the amateur, but he must be careful to see that the positive pole of the accumulator be joined to the positive pole of the source of supply—see figs. 19, 20, and 23. When charging from a dynamo the machine must be run up to its proper voltage before switching on to the accumulators.

In Fig. 26 is shown a Crocker & Wheeler's latest pattern low-voltage secondary dynamotor for charging storage batteries, fitted with automatic cut-off switch to protect the batteries. Dynamotors are used for charging storage batteries from power obtained from the ordinary lighting circuits of the building, and as the machine may be wound to give the exact voltage required to charge the battery, it is not necessary to cut down the full pressure of the lighting circuit to suit it by means of wasteful resistances, which has formerly been the practice, often involving a loss of over one-half and sometimes as much as nine-tenths of the energy. By the circuit opener, the connection to the battery is immediately broken by a slight motion of one of the field magnets of the ma-

chine, which is pivoted for this purpose, and is actuated to move outwardly from the armature by an adjustable spring when the current

FIG. 26.—DYNAMOTOR FOR CHARGING BATTERIES.

is off. When the lighting current returns and the machine starts up again, the field magnet moves in to the armature and closes the battery circuit and continues the charging.

Duration of Charging.—During charging the specific gravity of the electrolyte will slowly rise until it reaches 1.186, when the cells are fully charged, and will then gas freely, the acid turning very milky. The E.M.F. of each cell will rise till it reaches 2.25 volts when the cell is charged.

If any cell is found not to gas freely, it must be disconnected and carefully examined, any detached particles of oxide between the plates being carefully removed.

The time taken to charge cells depends on the capacity. The capacity of an accumulator is measured in ampère-hours, so that an accumulator having a capacity of 20 ampère-hours would be able to supply a current of 1 ampère for twenty hours, or 2 ampères for ten hours. Let us take an example from the following:

Capacity of accumulator, 40 ampère-hours. Resistance can be neglected. Back E.M.F. of cell = 2.25. No. of cells to be charged in series, 10. Resistance of dynamo, 5 ohms. The current that will pass through the storage cells is:

$$(C = \frac{E}{R} \text{ Ohm's law}).$$

$$C = \frac{25 - (10 \times 2.25)}{5} = \tfrac{1}{2} \text{ ampère.}$$

Now the capacity of each cell is 40 ampère-hours, therefore, time taken to charge the cells is:

$$\frac{40}{0.5} = 80 \text{ hours.}$$

If, however, a current of 4 ampères is sent through the cells, they will be charged in

$$\frac{40}{4} = 10 \text{ hours.}$$

This would be the case if the resistance of the dynamo was .625 ohms (5 ohms is a very high resistance for a dynamo), for then

$$C = \frac{25 - (10 \times 2.25)}{.625} = 4 \text{ ampères.}$$

The following instance may be given of a cell having seven plates (three positive and four negative), each plate being 6 ins. by 4 ins. The capacity was found to be about 10 ampère-hours. The maximum charging current for this cell being 4 ampères, the time taken to charge it $= \frac{10}{4} = 2\frac{1}{2}$ hours. The actual time taken was 2 hours 35 minutes.

Hints on Discharging.—During discharging, the specific gravity of acid will slowly fall. In no case must the cells be allowed to discharge below 1.9 volts per cell. When this state of

things is reached, discharging should be at once stopped and the cells recharged as soon as conveniently possible. "Sparking" and "flashing" cells to see if they are charged is very detrimental; it should never be done. A handy method of roughly telling if cells are charged or not is to have a 2-volt lamp and connect it across any cell to be tested. If the cell is fully charged the lamp will glow very brightly, but if the cell requires charging the lamp will be somewhat dim. A portable voltmeter, however, is far more handy. Pocket accumulators should be charged just before they are wanted, as the charge will leak through the damp lid. If the cells are discharged too heavily the plates will "buckle."

General Hints.—If cells have to be put out of work for a time, they should previously be fully charged, care being taken that the plates are covered with the electrolyte (acid). A short charging should be given, say once every three weeks. This will keep the cells in good order. There is a mistaken notion that cells will last longer if they are never fully charged. Over-charging will do no harm at all, provided the charging current be not excessive. It has, however, been clearly proved that nothing tends more to destroy cells than partly charging

them, and then exhausting them. When cells have begun to "sulphate" the only remedy is to over-charge them, and so get rid of the sulphate. By "sulphating" is meant the formation of white patches of insoluble sulphate of lead on the plates. It is due to neglect of the cells and careless management. If it appears, the plates should be carefully scraped, and then over-charged. In order to prevent "sulphating," caustic soda is often added to the acid. About 1 oz. to the 5 gallons of electrolyte should be added, and it is best to add it in the form of solution—say 1 oz. of caustic soda to 5 ozs. of water. To prevent "spraying" of the acid during charging, it is well to place sheets of glass over the plates to throw back any spray.

The room in which the cells are charged should be well ventilated, and metal work should not be exposed to the acid vapour, or it will be rapidly corroded. In order to protect the brass connecting parts, they should be coated with hot paraffin wax.

On no account should the accumulators be charged in a workshop, or the tools will be sure to suffer. If the charging or discharging current be too great the paste will be driven out of the grids.

Accumulators should always be kept in an upright position.

Do not charge the accumulators without being sure that every compartment has the right amount of acid.

Never thoroughly discharge battery, but when the light is getting dim place the accumulator on charge.

A piece of metal or wire placed across the two terminals, thus making a "short-circuit," is likely to injure the cell permanently.

When charging pocket accumulators as described in Chapter II., the plugs should be removed from the vent holes.

Charged positive plates have a chocolate colour, and it is usual to paint their lugs red. *Charged negative plates* are of a pale slate colour, and their lugs are painted black.

On no account should an accumulator be charged in the wrong direction, nor yet with too strong a current. With pocket accumulators the latter evil may be detected by feeling the outside of the cell with the hand. If the cell seems to be getting warmer, the current is too strong.

CHAPTER VI.

THE APPLICATIONS OF SMALL ACCUMULATORS.

THE applications of small accumulators to domestic, scientific, and general industrial requirements are many. Their extreme compactness, in most cases, renders them far more convenient for use than a primary battery or group of primary cells giving the same output, and, indeed, were it not for the possibilities of electric storage afforded by accumulators, many very useful appliances could not be made in anything like a practicable shape. One of the commonest domestic applications of small accumulators is for a bed-room night-light. A small incandescent lamp is mounted on a watch-stand or in other convenient position, and is connected by wires to the terminals of a small accumulator of suitable voltage. Somewhere in the circuit a push or small switch is inserted, which, when moved, turns the light off or on as required. When used for inter-

mittent work of this kind, one charging is usually sufficient to last for several weeks. Accumulators of a slightly larger kind may be turned to useful account in the household for driving small electro-motors, which in turn

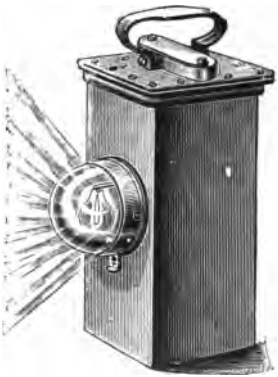


FIG. 27.—DOMESTIC ELECTRIC HAND LAMP.

work ventilating fans, sewing-machines, mincing or chopping machines, etc.

Portable electric lamps, for which the current is derived from a small secondary cell, are also very widely used. Such a lamp suitable for domestic use is shown in fig. 27. This is made up of a plain cell accumulator fitted and sealed into a highly polished wooden case with metal lid. A handle is affixed to the latter and

also a safety lock. The lamp is made detachable, with a hook at the back and a connecting cord and plug. This enables it to be used at a distance from the battery or loosely hung on a bracket at the side. The switch for turning the light on and off is contained in the case of the lamp. Lanterns of this pattern are also made in which the lamp is a fixture on the front of the battery case. The positive charging terminal is then covered by a lug fitted to the battery lid and is only accessible when the lid is unlocked. The negative charging terminal is reached through a small hole in the switch, but can only be got at when the switch is in the "off" position. This prevents the charging current from passing through the incandescent lamp.

For use in a photographic dark-room, such a lantern is admirably adapted if the lamp be fitted with a cap containing orange or ruby glass, so as to render the light non-actinic. Photographers will readily appreciate the advantages of being able to switch the light on or off at will without having to strike a match, and also the absence of smoke, smell, and heat.

For factory, gas-works, and aboard ship use, lamps are made of the type shown in fig. 28. These are similar to the domestic lamps pre-

viously described, but have no metal lid nor locking arrangement. For miners and firemen, something of a stronger and more damp-proof character is required. Accordingly the accumulator cells are enclosed in strong metal cases, as in the lamp depicted in fig. 29. The bottom loops of the incandescent lamp are suspended

FIG. 28.—FACTORY ELECTRIC HAND LAMP.

on two elastic wire hooks which tend to open sideways, while a spring hook grips the point of the incandescent lamp and forces this against the hooks, thus ensuring an excellent contact. Should the outer glass of the lamp get broken by accident, the incandescent lamp is thrown off the hooks and thus breaks the

circuit before the lamp itself can break. Even should the lamp get broken, it has been ascertained, by numerous experiments, that the filaments of such small incandescent lamps cool instantaneously, and therefore it is quite impossible to cause an explosion of fire-damp in this way.

A different type of portable electric lamp is

FIG. 29.—MINER'S ELECTRIC HAND LAMP.

illustrated in fig. 30. Here the accumulator is carried in a small bag or satchel, C, which by means of the strap, S, may be slung across the user's shoulders. The lamp, L, is connected to the battery by a flexible twin-wire, and is provided with a fastening enabling it to be fixed

in a button-hole or to any portion of a person's clothes, thus allowing free use of both hands. Lamps of this pattern are much used by ticket inspectors in the employ of 'bus, tram, or railway companies, and also by meter readers in

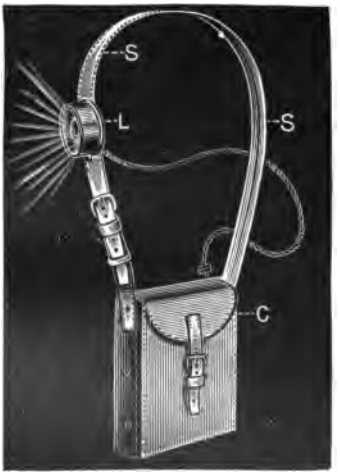


FIG. 30.—INSPECTOR'S ELECTRIC LAMP.

the service of gas and electric light companies. Private persons also find them useful as reading lamps when travelling at night-time.

One of the most popular uses of small accumulators is undoubtedly for cycle and carriage lighting. Electric lamps require no trimming,

neither are they blown out by the wind, nor easily jolted out when travelling over rough roads. Fig. 31 and fig. 32 show a small accumulator and lamp specially adapted for cycles. The battery is a 4-volt ebonite rectangular one, and will give a good light for about eight

FIG. 31.—ACCUMULATOR IN CASE, FOR CYCLE LAMP.

hours. The plates are raised about ¼ in. from the bottom of the cell, and are faced with flat perforated sheet celluloid to prevent any of the active material being jolted from the grids. The terminals are protected by an ebonite covering to protect them from the corrosive action

of the acid. The leather case is made from a stout superior hide, and the interior is coated with an india-rubber compound. The joints or seams are fastened with nickel-plated rivets, no stitching of any kind being employed. The straps for attaching the case to the frame of the cycle pass right round as shown, thus supporting the whole weight. The lamp is

FIG. 32.—CYCLE LAMP AND CONNECTIONS.

mounted in a nickel silvered outer case, to which is fitted an ebonite back. To the back is attached a tongue clip and a detachable screw switch for making contact. The connection to the battery is made by flexible leads, the ends of which are neatly finished off in ebonite. Fig. 33 shows an electric cycle lamp, of somewhat different design, placed in position on the wheel. In this case it will be noticed that the accumulator is suspended under-

neath the saddle, though not infrequently the handle bar or top cross bar of the frame is the

FIG. 33.—ELECTRIC CYCLE LAMP.

selected point of support, as shown in fig. 34. Other patterns of electric cycle lamps are also

made similar in form to the usual oil-burning lamps. In these the battery is contained in a metallic case, which fits on to the lamp-bracket of the bicycle, the lamp itself being fixed to the front of the accumulator case.

For the lighting of carriage lamps, accumulators of a larger kind, as shown in fig. 35, are required. These are fitted in teak cases, and

FIG. 34.—ELECTRIC CYCLE LAMP.

are arranged to give either 8, 10, 12, or 16 volts, according to the lamps employed. Their capacity is about twelve ampère-hours. The over-all dimensions of the largest size is $13\frac{3}{4} \times 5 \times 7$ ins. The lamp itself is of the usual carriage pattern, but adapted, of course, to receive an incandescent lamp.

A very neat form of carriage lamp is shown

in the illustration, fig. 36. This is fixed to the end of the carriage pole, and is specially con-

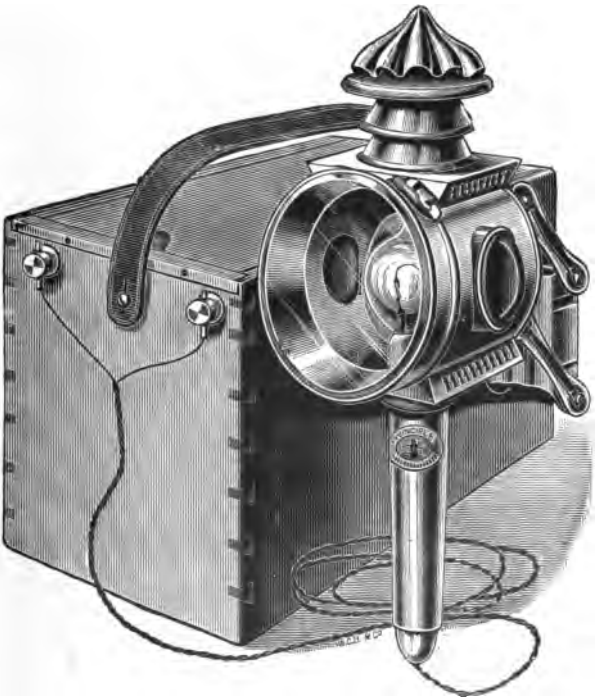


FIG. 35.—ELECTRIC CARRIAGE LAMP.

structed to withstand the severe jolting it receives in such a position without interfering

with the light. The lantern itself is fastened to a strong hollow iron bracket, which is screwed on to the under side of the pole. The connecting wire, which comes out of the bracket, is run along a fine groove in the pole, or through small eyelets, and has at the other end a concentric plug arrangement which enables connection with the carriage wire to

FIG. 36.—ELECTRIC LAMP ATTACHED TO CARRIAGE POLE.

be easily made, as also disconnection when the pole has to be removed.

Of recent years, portable accumulators have been much employed for obtaining brilliant lighting effects on the stage, and one device of this kind, termed a ballet star, appears in fig. 37. This consists of a tiny incandescent lamp fixed in the centre of a brilliant metal star, the whole being mounted on a band which fits the

dancer's head. For this work, it is necessary to use a dry electrolyte in the accumulator to avoid any damage due to the spilling of acid. The accumulator is carried on the body by means of a strap or belt, and a flexible lead, with a small push or switch, enables the light to be switched on or off as desired. Electrically-lighted wands are also constructed on similar lines for theatrical use.

Some very pretty effects may be obtained with electric jewellery of the kind shown in

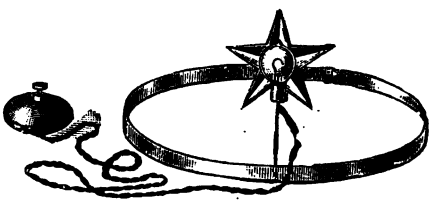


FIG. 37.—BALLET STAR.

fig. 38 and fig. 39. Scarf-pins, hair ornaments, studs, brooches, floral buttonholes, all lend themselves to electric illumination, and a small 4-volt pocket accumulator is amply sufficient to supply the necessary current.

The apparatus represented by fig. 40 is quite a novelty in the application of small accumulators, as it is intended to attract fish to the

bait when angling. It consists of an incandescent lamp with a special water-proof fitting, attached to a length of flexible wire which can be lowered to any depth in the water. It is

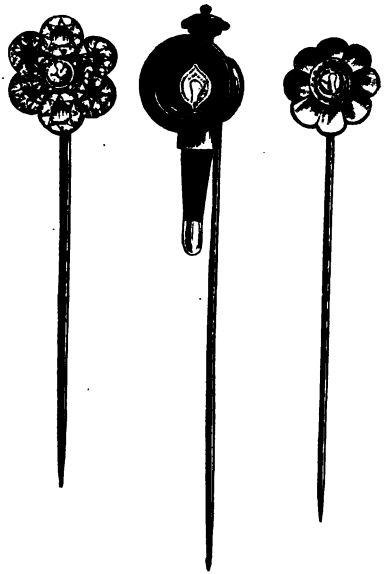


FIG. 38.—ELECTRIC SCARF-PINS.

stated that the fish will gather in great numbers round the light.

There are many other applications of small accumulators which, however, cannot be dealt

with at any length within the modest limits of this book. The following list will indicate

FIG. 39.—ELECTRIC HAIR-PINS.

some of these, and may be of interest as showing the extensive field in which the original

researches of Grove, Planté, and Faure have enabled beneficial results to be achieved :—Medical purposes—for examining internal portions of the human body, for cautery operations, and for working X-ray coils; for lighting objects under the microscope; for reading lamps for lecturers; for lighting table decora-

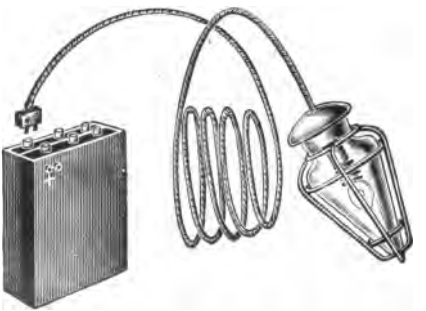


FIG. 40.—FISHING LAMP.

tions; for sterilising water; for igniting the explosive charge in gas and oil-engines; for electrical testing work; for lighting house-boats; for boat and ship's side and mast-head lights; and for divers' lamps. The ready comprehension of the construction and proper using of each or all of such appliances, involving the employment of small accumulators, will, it is hoped, not come amiss to the reader

who has perused with due care the information contained in the preceding pages.

We might mention two books on this subject that would prove of interest to our readers: A pamphlet by Buell on "The Storage of Electrical Energy," and Reynier on "The Voltaic Accumulator," an elementary treatise, translated from the French by J. A. Berley. Both of these can be had from the publishers of this book.

USEFUL RECEIPTS AND MEMORANDA.

Pole Testing Paper.—Make a thin solution of white starch and soak strips of thin white blotting-paper in it, and set aside in a clean place to dry. Dissolve ½ oz. of potassium iodide in 1 pint of water. Immerse the strips in the solution for a few seconds and again dry. This paper, when moistened and used in the usual way, turns violet at the positive pole.

Varnish.—A good varnish is made of 1 lb. of shellac dissolved in 1 pint of polisher's finish. It forms a tough, coherent surface and adheres strongly if the article to be coated is warmed before the varnish is used. It is best to apply it in two or three thin coats, allowing each coat to dry, rather than in one thick coat.

Beeswax Compound.—Equal parts of beeswax and resin well boiled and used hot.

Insulating Cement.—A good cement is made for Leyden jars and insulating stands: Sulphur, 100 parts; tallow, 2; resin, 2 parts, melted together until of the consistency of syrup, and sufficient powdered glass added to make a paste. This

cement must be heated when applied, and will be found to resist most acids.

Marine Glue.—Pure India-rubber (cut small), 1 part; coal-tar naphtha, 12 parts; digest in a covered vessel with gentle heat and agitation, and when thoroughly dissolved add powdered shellac 20 parts. Continue the heat and stirring until perfect liquefaction has taken place and pour the fused mass, while still hot, on slabs of polished metal or stone, so as to form thin sheets. When required for use heat in an iron vessel to its melting-point, 248° to 250° F. and apply in a liquid state with a brush. It can be made as hard as required by increasing the proportion of shellac.

INSULATING MATERIALS.

Asbestos.—Good for covering other materials where there is a liability of sparking, also for covering wires that are liable to heat. Asbestos cloth, coated with shellac, is rendered impervious to moisture.

Ebonite has powerful insulating and dielectric properties, but air and especially ozone react on the sulphur and render its surface conducting, but a coating of strong varnish will prevent this.

Celluloid.—Very good for constructing battery cells, etc., and easily cemented together by a solution of itself. It should be remembered, however, that it is very inflammable.

Gutta-percha.—When exposed to air for a time it oxidizes and becomes brittle, but when entirely

under water it is good and appears practically indestructible.

Glass varies very much in its properties, but a coating of good varnish where possible improves its insulation. It should be warmed before applying the varnish.

Ozokerit.—A mineral substance closely resembling paraffin, but inferior.

Paraffin.—One of the most valuable substances known for insulating.

Silk, Cotton, and India-rubber are also used for insulating material.

To Insulate Copper, Brass, or Iron.—The method of obtaining this insulating material is, from an industrial point of view, very practicable and cheap. The hardness of this coating, which resists all atmospheric action, is a guarantee of its durability. *The insulation is absolute.* A bath of plumbate of potash is prepared by dissolving 10 parts of litharge in 1000 parts of water, to which has been added 200 parts of caustic potash, then boil for about 30 minutes. Allow to settle and decant; it is then ready for use. The metal to be coated with peroxide of lead is attached to the positive pole and a small platinum anode to the negative, and both poles placed in the above-mentioned bath. Finely divided metallic lead is precipitated upon the negative pole, and the metal is coated with peroxide of lead. The metal passes successively through all the colors of the spectrum, and when it takes on a brownish-black color the insulation is complete.

GLOSSARY OF TECHNICAL TERMS.

Ampère.—The unit (for practical work) of electric current.

Ampère-hour.—A practical unit of quantity; being the quantity which a current of one ampère would carry past a given point in one hour.

Battery.—A combination of two or more cells.

Buckling.—A term, whose meaning is evident, technically applied to the distortion of accumulator plates by badly distributed current.

Cell.—A chemical generator of electrical energy.

Ebonite.—A black, hard preparation of indiarubber (Vulcanite).

Electrodes.—The conductors by which current enters and leaves an apparatus: Anode = entering; Cathode = leaving electrode.

Electromotive-force.—That which moves or tends to move electricity; the electrical equivalent of mechanical pressure.

Electrolysis.—Chemical decomposition caused electrically.

Electrolyte.—The conducting medium between electrodes which undergoes electrolysis.

Element.—The active electrode of a cell.

E.M.F.—Abbreviation for electromotive-force (see above).

Grid.—The skeleton framework of an accumulator plate.

Lead Peroxide.—An oxide of lead whose chemical symbol is PbO_2.

Litharge.—Lead protoxide; PbO.

Minium.—Red lead; Pb_3O_4.

Negative.—Pole, terminal, plate, etc., the pole, terminal or plate by which the current returns to a generator or leaves an instrument.

Ohm.—The unit (for practical work) of electrical resistance.

Paraffin wax.—A white mineral wax; a good insulator and a protector against acid (strictly speaking should be called "paraffin").

Parallel.—Circuits are in parallel between two points when the current entering at one point divides, a portion flowing through each circuit, and the portions reunite at the other point.

Pole.—Equivalent to terminal.

Pole-testing Paper.—Used for determinating the positive and negative poles of accumulators.

Positive.—The converse of "negative," *i.e.* "outgoing" as applied to a generator, "ingoing" of an instrument.

Resistance.—Self-evident term applied to electrical friction.

Series.—Circuits are in series when the *same current* flows through all the circuits; cells in series are connected + ve of one cell to — ve of next.

Short-circuit.—A path of extremely low resistance, or practically none; sometimes abbreviated to "short." To provide a short circuit.

Spatula.—An instrument like a spoon with a flat bowl.

Terminal.—The connecting screw by which a conductor is connected electrically.

Thermopile.—An electric generator excited by heat.

Volt.—The unit (for practical work) of electrical pressure.

Vulcanite.—Another name for ebonite, which see.

USEFUL BOOKS

Barometer.—The barometrical determination of heights. A practical method of barometrical levelling and hypsometry, for surveyors and mountain climbers. By Dr. F. J. B. Cordeiro, U. S. N. 12mo, leather, 1.00

Dynamo.—Notes on the design of small dynamo, with complete set of drawings to scale. By G. Halliday. 79 pages, illustrated, 8vo, cloth, ... 1.00‡

Electric Bells.—A treatise on the construction of electric bells, indicators and similar apparatus. By F. C. Allsop. 131 pages, 177 illustrations, 12mo, cloth, ... 1.25

Electric Bells.—Practical electric bell fitting. A treatise on the fitting up and maintenance of electric bells and all their necessary apparatus. By F. C. Allsop. 170 pages, 186 illustrations, 12mo, cloth, . . . 1.25

Electrical Notes.—Practical electrical notes and definitions, for the use of engineering students and practical men. By W. Perren Maycock, E.E. 286 pages, illustrated, 32mo, cloth, ...75

Electricity.—Comparisons between the different systems of distributing electricity. By Prof. Henry Robinson. 8vo, paper, . . .80

Galvanometer.—A series of lectures on the galvanometer and its uses, delivered by Prof. E. L. Nicols, and used by him in his class at Cornell University. 112 pages, 76 illustrations, 8vo, paper, ... 1.00

Induction Coils, and coil making. A treatise on the construction and working of shock, medical, and spark coils. By F. C. Allsop. 172 pages, 124 illustrations, 12mo, cloth, 1.25

Measurements.—A systematic treatise on electrical measurements. By H. C. Parker. 120 pages, 96 illustrations, 8vo, cloth, . 1.00‡

Mining.—Electricity in mining. Its practical applications to all the different operations of drilling, blasting, lighting, haulage, pumping as applied to mining. By Prof. Silvanus P. Thompson, D.S.C. 45 pages, 11 illustrations, 8vo, paper, ...80

Phonograph.—The phonograph and how to construct it, and a chapter on sound, with full set of working drawings. 12mo, cloth, 2.00

Transformer.—History of the transformer, translated from the German. By F. Uppenborn. 60 pages, 31 illustrations, 12mo, .75

Transformer.—Transformer design, a treatise on their design, construction and use. By H. Adams. In the work the author has avoided as much as possible all historical matter and unnecessary mathematical problems, and has confined himself to practical experience. The work contains much information that will prove of value to the draughtsman, designer and electrical student. Second edition. 75 pages, 34 illustrations, 12mo, cloth, ... 1.50‡

RUHMKORFF

INDUCTION COILS

Their Construction, Operation and Applications, with Chapters on

BATTERIES, TESLA COILS AND ROENTGEN RADIOGRAPHY . . .

By H. S. NORRIE

CONTENTS OF CHAPTERS:

Chapter I.—Coil Construction. II.—Contact Breakers. Pole Charging Breaker. III.—Insulations and Cements. IV.—Condensers. Paper Condensers. Series Condensers. V.—Experiments. Luminous Designs. VI.—Spectrum Analysis. VII.—Currents in Vacuo. Discharges in Vacuo. VIII.—Rotating Effects. IX.—Gas Lighting and Ozone Production. X.—Primary Batteries and Electric Light Currents. XI.—Storage Batteries or Secondary Cells. Charging Storage Batteries. Charging from Primary Batteries. Setting up the Storage Cell. XII.—Tesla and Hertz Effects. XIII.—Roentgen Rays and Radiography. With 57 new illustrations. Index.

183 pages, 12mo, cloth, 50 cents.

EVERYBODY'S BOOK ON ELECTRICITY

PRACTICAL ELECTRICS

A UNIVERSAL HANDY-BOOK

ON

EVERYDAY ELECTRICAL MATTERS

FIFTH EDITION

CONTENTS:

Alarms.—Doors and Windows; Cisterns; Low Water in Boilers; Time Signals; Clocks. *Batteries.*—Making; Cells; Bichromate; Bunsen; Callan's; Copper-oxide; Cruikshank's; Daniel's; Granule carbon; Groves; Insulite; Leclanché; Lime Chromate; Silver Chloride; Smee; Thermo-electric. *Bells.*—Annunciator System; Double System; and Telephone; Making; Magnet for; Bobbins or Coils; Trembling; Single Stroke; Continuous Ringing. *Connections. Carbons. Coils.*—Induction; Primary; Secondary; Contact-breakers; Resistance. *Intensity* Coils.—Reel; Primary; Secondary; Core; Contact-breaker; Condenser; Pedestal; Commutator; Connections. *Dynamo-electric Machines.*—Field-Magnets; Pole-pieces; Field-magnet Coils; Armature Cores and Coils; Commutator Collectors and Brushes; Relation of size to efficiency; Methods of exciting Field-Magnets; Magneto-Dynamos; Separately excited Dynamos; Shunt Dynamos; Field-Magnets; Armatures; Collectors; Brush Dynamo; Alternate Currents. *Fire Risks.*—Wires; Lamps; Danger to persons. *Measuring.*—Non-Registering Instruments; Registering Instruments. *Microphones. Motors. Phonographs. Photophones. Storage. Telephones.*—Forms; Circuits and Calls; Transmitter and Switch; Switch for Simplex; etc., etc.

135 PAGES. 126 ILLUSTRATIONS. 8VO.

Cloth, 75 cents

THE VOLTAIC ACCUMULATOR

AN ELEMENTARY TREATISE

BY ÉMILE REYNIER

TRANSLATED FROM THE FRENCH

BY J. A. BERLY, C.E., A.I.C.E.

CONTENTS

PART I.—PRINCIPLES. Definitions. Voltameters. Classification of Accumulators.

PART II.—VOLTAIC ACCUMULATORS. Planté Accumulators. Accumulators of the Planté type. Autogeneous formation. Heterogeneous formation. Miscellaneous Accumulators.

PART III —TECHNOLOGY. Technical generalities concerning Accumulators. Formula of merit of a system of Accumulators.

PART IV.—Applications of Accumulators. General remarks on the charge of Accumulators. First applications of secondary couples by Mr. G. Planté. Applications to scientific researches, to telegraphy, telephony, clockwork, etc. Application to electric lighting, and to the current regularization of machines; regulating voltameters. Welding of metals. Production of motive-power. Electrical locomotion on tramways and on roads. Electrical navigation. Transmission and Distribution of energy by means of secondary currents. Translation or displacement of energy by means of Accumulators. Land carriage of energy. Water carriage of energy. Caption of natural forces by means of Accumulators.

202 pages, 62 illustrations, 8vo, cloth, $3.00.

SMALL ACCUMULATORS

How Made and Used

A Practical Handbook for Students and Young Electricians

EDITED BY PERCIVAL MARSHALL, A.I.M.E.

Contents of Chapters

I.—The Theory of the Accumulator.
II.—How to make a 4-Volt Pocket Accumulator.
III.—How to make a 32-Ampere-Hour Accumulator.
IV.—Types of Small Accumulators.
V.—How to Charge and Use Accumulators.
VI.—Applications of Small Accumulators, Electrical Novelties, etc. Useful Receipts. Glossary of Technical Terms.

80 pages, 40 illustrations, 12mo, cloth, 50c.

THE MAGNETO-TELEPHONE

ITS CONSTRUCTION,

Fitting Up and Adaptability to Every-Day Use

BY NORMAN HUGHES

CONTENTS OF CHAPTERS

Some electrical considerations: I.—Introductory. II.—Construction. III.—Lines, Indoor Lines. IV.—Signalling Apparatus. V.—Batteries. Open Circuit Batteries. Closed Circuit Batteries. VI.—Practical Operations. Circuit with Magneto Bells and Lightning Arresters. How to Test the Line. Push-Button Magneto Circuit. Two Stations with Battery Bells. VII.—Battery Telephone. Battery Telephone Circuit. Three Instruments on one Line. VIII.—General remarks. Index.

80 pages, 23 illustrations, 12mo, cloth, $1.00. In paper, 50c.

Cleaning and Scouring

A MANUAL FOR

DYERS AND LAUNDRESSES

And for Domestic Use.

BY S. CHRISTOPHER.

CONTENTS.

DRESSES.—Silk, Satin, Irish Poplin and Tabinet, Lama, Alpaca, Printed Muslin and Pique, Pique and Colored Muslin.

SHAWLS AND SCARVES.—China Crape, Brocaded or Printed Silk, and Woolen.

SILK HANDKERCHIEFS, RIBBONS, MANTLES, FANCY WAISTCOATS, AND LACE. GLOVES.—Kid, Washleather.

FEATHERS.—White, Colored; to purify—for Beds, &c.

BONNETS.—Chip, Straw, and Leghorn. ANCIENT TAPESTRY.

CURTAINS, BED FURNITURE, &C.—Chintz, Damask, Worsted-and-cotton Damask, French Damask—Silk-and-worsted Moreen, Tabaret or Tabbarea, Satin, Tammy Lining, Fringes—Bullion and worsted, Lace and Gimp—Bullion.

TABLE COVERS.—Silk-and-worsted, Cotton-and-Worsted, and Printed Cloth.

CARPETS.—Dry Cleaning, thorough Cleaning.

HEARTHRUGS, SHEEPSKIN RUGS AND MATS.

TO REMOVE VARIOUS STAINS FROM LINEN AND COTTON.—Fruit Stains, Grease Spots, Ink Stains, Marking Ink, Mildew, Paint or Varnish, Wine Stains.

RECIPES FOR GENERAL DOMESTIC USE.—Oilcloth, Paint, Floors, Marble, Iron and Steel, Brass or Copper, Silver Plate, Furniture, Gilt Frames, Ivory Ornaments, Mirrors, Wall-paper, Stone Steps.

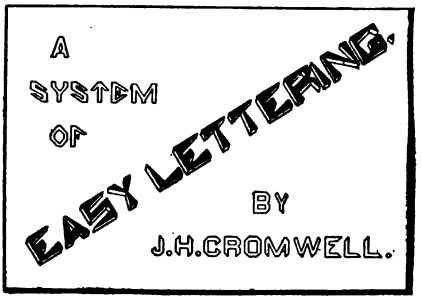
DEFINITIONS, &C.—Boards, &c., for French Cleaning, Camphine, Common Sour, Drying, Frame, French Board, Hot Stove, Irons, Parchment Size, Pegs, Puncher, Size, Soap, Starch, To Handle, To Sheet-up, Water.

Price 20 cents, post-paid.

NEW

EDITION "DE LUXE"

ON HEAVY PLATE PAPER



ITS GOOD POINTS.

Very easy to learn.

A rapid method to become a good letterer with a little practice.

Very easy to lay out a line of words in STRICT PROPORTION, whether it be on a fence 500 yards long or on a drawing only a few inches across.

Good for draughtsmen who prefer neat lettering, yet something out of the ordinary.

It contains 26 pages of alphabets whose modifications are almost limitless.

One of the cheapest in the market.

This little book will be appreciated by draughtsmen who wish to use plain letters (and yet somewhat different from the ordinary run of letters) for the titles on drawings. The book will also be valuable and useful to any one who has had no practice in lettering, as the easy method given for forming the letters will enable a person to form the letters correctly, and with a little practice to do so quickly.—*American Machinist.*

Oblong, 8vo, cloth, 50 cents

Manual of Instruction in

Hard Soldering

WITH AN APPENDIX ON THE

Repair of Bicycle Frames

Notes on Alloys and a Chapter on Soft Soldering

BY HARVEY ROWELL

The flame, lamp, charcoal, mats, blow-pipes, wash-bottle, binding wire, chemicals, borax, spelter, silver solder, gold solder, oxidation of metals, fluxes, anti-oxidisers, oxidation of cases, the cone, oxidising flame, reducing flame, heat transmission, conduction, capacity of metals, radiation, application, the work table, the joint, applying solder, applying heat, the use of the blow-pipe, joints, making a ferrule, to repair a spoon, to repair a watch case, hard soldering with a forge or hearth, hard soldering with tongs, preserving thin edges, silversmith's pickle, restoring color to gold, chromic acid, to mend steel springs, sweating metals together, retaining work in position, making joints, applying heat, preventing the loss of heat, effect of sulphur lead and zinc, to preserve precious stones, annealing and hardening, burnt iron, to hard solder after soft solder. Tables of—specific gravity, tenacity, fusibility, alloys.

66 pages, illustrated, cloth, 75 cents.

For Soldering Receipts, Cements and Lutes, Pastes, Glues and such like, *see* WORKSHOP RECEIPTS.

The Best and Cheapest in the Market

ALGEBRA SELF-TAUGHT

FOR THE USE OF

Mechanics, Young Engineers and Home Students

BY W. PAGET HIGGS, M.A., D.Sc.

FOURTH EDITION

CONTENTS

Symbols and the signs of operation. The equation and the unknown quantity. Positive and negative quantities. Multiplication, involution, exponents, negative exponents, roots, and the use of exponents as logarithms. Logarithms. Tables of logarithms and proportional parts. Transportation of systems of logarithms. Common uses of common logarithms. Compound multiplication and the binomial theorem. Division, fractions and ratio. Rules for division. Rules for fractions. Continued proportion, the series and the summation of the series. Examples. Geometrical means. Limit of series. Equations. Appendix. Index. 104 pages, 12mo, cloth, 60c.

See also **Algebraic Signs,** Spons' Dictionary of Engineering, No. 2. 40 cts.

See also **Calculus,** Supplement to Spons' Dictionary, No. 5. 75 cts.

PRACTICAL HANDBOOK ON

Gas Engines

With Instructions for Care and Working of the Same.

BY G. LIECKFELD, C.E.

Translated with permission of the Author by

GEORGE RICHMOND, M.E.

WITH A CHAPTER ON OIL ENGINES

CONTENTS

Choosing and installing a gas engine. The construction of good gas engines. Examination as to workmanship, running, economy. Reliability and durability of gas engines. Proper erection of a gas engine. Foundation. Arrangement for gas pipes. Rubber bag. Locking devices. Exhaust pipes. Air pipes. Setting up gas engines. Brakes and their use in ascertaining the power of gas engines. Arrangement of a brake test. Distribution of heat in a gas engine. Attendance on gas engines. General remarks. Gas engine oil. Cylinder lubricators. Rules as to starting and stopping a gas engine. The cleaning of a gas engine. General observations and specific examination for defects. The engine refuses to work. Non-starting of the engine. Too much pressure on the gas. Water in the exhaust pot. Difficulty in starting the engine. Irregular running. Loss of power. Weak gas mixtures. Late ignition. Cracks in air inlet. Back firing. Knocking and pounding inside of engine. Dangers and precautionary measure in handling gas engines. Precautions when opening gas valves, removing piston from cylinder, examining with light openings of gas engines. Dangers in starting, cleaning, putting on belts. **Oil Engines.** Gas engines with producer gas. Gasoline and oil engines. Concluding remarks.

120 pages, illustrated, 12mo, cloth, $1.00.

THE
FIREMAN'S GUIDE

A Handbook on the Care of Boilers

BY KARL. P. DAHLSTROM, M.E.

CONTENTS OF CHAPTERS

I. Firing and Economy of Fuel.—Precautions before and after starting the fire, care of the fire, proper firing, draft, smoke, progress of firing, fuel on the grate, cleaning out, cleaning grate bars and ash pan, dampers, firing into two or more furnaces, dry fuel, loss of heat.

II. Feed and Water Line.—Feeding, the water line, false water line, defective feeding apparatus, formation of scale, gauge cocks, glass gauge, the float, safety plug, alarm whistle.

III. Low Water and Foaming or Priming.—Precautions when water is low, foaming, priming.

IV. Steam Pressure.—Steam gauge, safety valves.

V. Cleaning and Blowing Out.—Cleaning the boiler, to examine the state of the boiler, blowing out, refilling the boiler.

VI. General Directions.—How to prevent accidents, repairs, the care of the boiler when not in use, testing boilers, trimming and cleaning outside. Summary of rules. Index.

8vo, cloth, 50 cents.

HOW TO RUN

Engines and Boilers

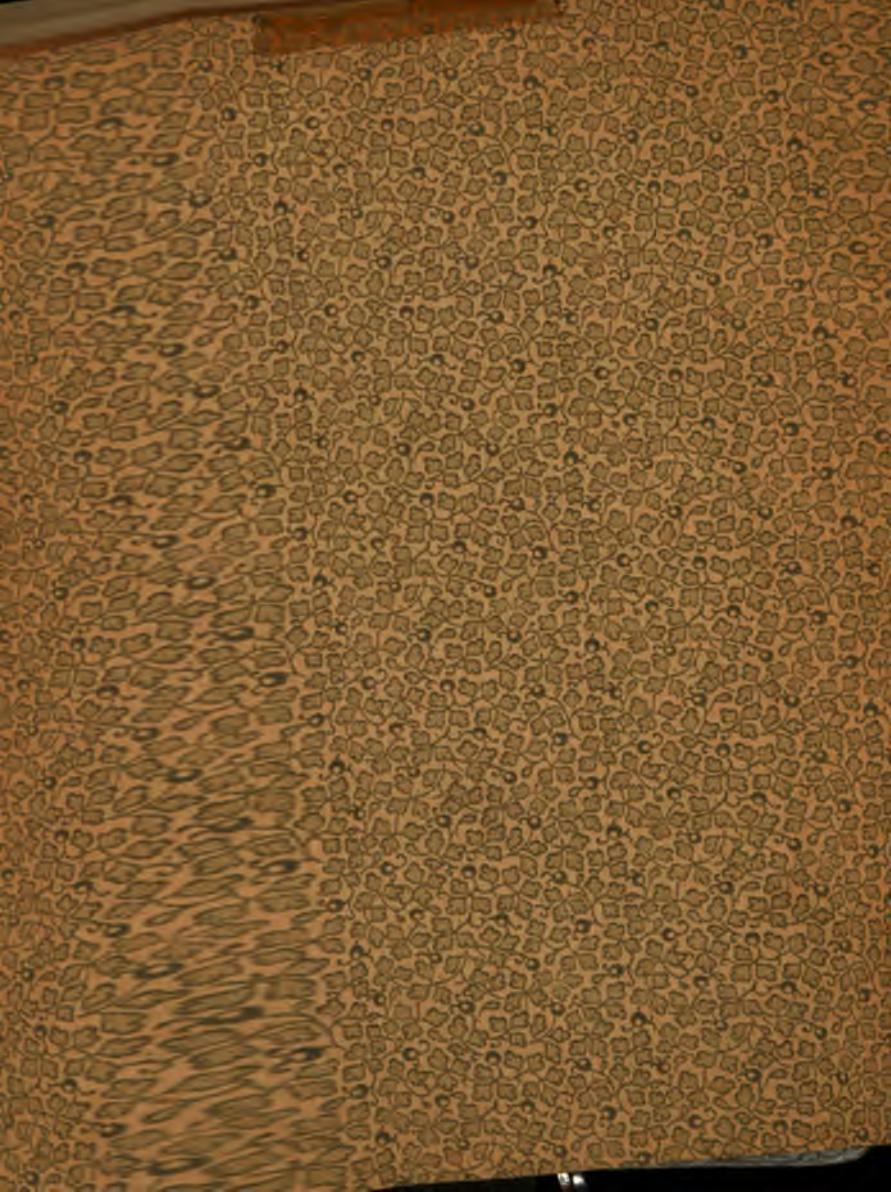
Practical Instruction for Young Engineers and Steam Users.

BY EGBERT POMEROY WATSON

REVISED AND ENLARGED

Synopsis of Contents

Cleaning the boiler, removing scale, scale preventers, oil in boilers, braces and stays, mud drums and feed pipes, boiler fittings, grate bars and tubes, bridge walls, the slide valve, throttling engine, the piston, testing the slide valve with relation to the ports, defects of the slide valve, lap and lead, the pressure on a slide valve, stem connections to the valve, valves off their seats, valve stem guides, governors, running with the sun, eccentrics and connections, the crank pin, brass boxes, bearings on pins, adjustment of bearings, the valve and gearing, setting eccentrics, the actual operation, return crank motion, pounding, the connections, lining up engines, making joints, condensing engines, Torricelli's vacuum, proof of atmospheric pressure, pumps, no power in a vacuum, supporting a water column by the atmosphere, starting a new plant, the highest qualities demanded.

Water tube boilers, fire tube boilers, why water tube boilers steam rapidly, torpedo boat boilers, management of water tube boilers, economy and maintenance of water tube boilers.

150 pages, illustrated, 16mo, cloth, $1.00